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ABSTRACT

This paper cites information received from a number of sources, e.g., mathematics teachers in two-year colleges, publishers, and convention speakers, about the nature of discrete mathematics and about what topics a course in this subject should contain. Note is taken of the book edited by Ralston and Young which discusses the future of college mathematics and also of recommendations about discrete mathematics made by various groups. The paper notes that the inclusion of discrete mathematics into the curriculum has been advocated by many credible sources. The major topics included in such a course seem to be sets, propositional logic, formal systems such as groups, methods of proof, graph theory, trees, relations, functions, and basic combinatories. If probability is included, its coverage will not be in depth. Additional material includes analysis of algorithms, matrix algebra, predicate logic, boolean algebra, and additional probability and combinatorics. Outlines of books and survey results are appended. (MNS)

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WHAT IS DISCRETE MATHEMATICS?

by Professor Karen Tobey Sharp, Mott Community College, Flint, Michigan

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A number of factors have led me to the point of being a person to attempt to answer this question. First of all, several years ago I began to teach computer science courses on my campus. Of course, these classes are at this time mainly introductory programming classes. About three years ago I recognized the need for formal training in computer science. I was barely ahead of the students! In addition, plans have been made to introduce more vertical structure in our computer science classes by teaching more than just beginning programming classes. An AA degree in computer science is being contemplated. Concurrent with many of these developments, I received a sabbatical from my college for further study of computers. Accordingly, I am now slightly more than half way to a masters degree in computer science from The University of Michigan.

Last fall at the AMATYC Convention in Orlando, Florida, I was very interested in hearing that discrete mathematics was being advocated as a course to be taught at the two-year college in order to give computer science students a more adequate background for their studies. At the same convention, I was appointed by the AMATYC Executive Board as chairperson of a committee to plan its first summer workshop. One of the topics selected to be taught in 1985 at this summer workshop is discrete mathematics.

I have attempted to answer the question, "What is Discrete Mathematics?", by obtaining information from a number of sources. First of all, I asked questions about discrete mathematics of a number of persons in Orlando, Florida, at the AMATYC Convention last fall. It soon became apparent that the answer was not an easy one.

In January, 1984, I wrote to many publishers, including those that had a booth at the AMATYC Convention last year. I informed these publishers of our tentative

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plans for a summer workshop on discrete mathematics and the need to define that term more precisely. I indicated to these publishers that obtaining textbooks appropriate at the two-year level of study would help in this regard. From the thirty letters sent to publishers, I received fourteen replies. From seven publishers I received textbooks. The responses were as follow:

(1) Amsco School Publications, Inc. - no textbook at this time

(2) Brooks/Cole Publishers and Wadsworth Publishers - received Mathematics For Data Processing by Wheaton table of contents for Discrete Mathematics by Polimeni and Straight

(3) W. H. Freeman Publishers - received Mathematical Structures for Computer Science by Gersting

(4) D.C. Heath Publishers - received the Kenneth Bogart of Dartmouth College survey

(5) McGraw Hill Publishers - received Elements of Discrete Mathematics by Liu Applied Finite Mathematics by Gilbert & Koehler

(6) Macmillan Publishers - received Discrete Mathematics by Johnsonbaugh

(7) Kendall/Hunt Publishers - no textbook at this time

(8) Prentice-Hall Publishers - received Discrete Mathematical Structures for Computer Science by Kolman/Busby

(9) Prindle, Weber & Schmidt Publishers - several projects underway

(10) Reston Publishers - received Discrete Mathematics for Computer Scientists by Mott, Kandel, and Baker

(11) Scott, Foresman Publishers - received two prospectuses for discrete mathematics textbooks

(12) Springer-Verlag Publishers - no textbook at this time

(13) West - no textbook at this time

(14) Worth Publishers - no textbook at this time

To obtain additional information I attended the MAA Convention in January, 1984. I attended the presentation of the Panel on Discrete Mathematics in the First Two Years, which attempted to answer the same question as I am attempting to answer now. This panel presented the results of a survey on Discrete Mathematics conducted by Kenneth Bogart of Dartmouth College in conjunction with D.C. Heath Publishers.

As Professor Bogart states, "There was sufficient unanimity among the respondents [to this survey] to justify the statement that there is, or will be, a standard entry level course in discrete mathematics, and the majority of the content of the course is common to almost all institutions teaching the course [now]." His survey report outlined that common content.[4] This survey had a response level of 13% (3600 surveys and 475 responses). Virtually every institution answering the survey had introduced or is at least somewhat likely to introduce a "first-level" (as opposed to junior/senior level) course in discrete mathematics. At the end of this paper is a table indicating the 18 most popular topics for inclusion in a discrete mathematics course as per the respondants to this survey.

While admittedly most of these respondants were probably from four year schools, introducing freshman/sophomore level discrete mathematics classes will mean that two-year colleges will also. This same panel discussion at the MAA Convention presented additional findings. Of the 70 schools contacted only 9 had no discrete mathematics at all. These courses might not be called discrete mathematics but the content was what is now being recognized as discrete mathematics. The panel further indicated that the spirit of such a course should be problem solving and an introduction to abstraction. Finally, the course appears to be very similar to the finite math course as introduced thirty years ago by Kemeny, Snell and Thompson, before finite math became more like a liberal arts or math appreciation course.

At the same MAA Convention I attended a minicourse presented by Stephen Maurer of Swarthmore College and, at that time, of the Alfred P. Sloan Foundation. He advocates a discrete "algorithmic" mathematics. He believes that most of mathematics should be taught using an algorithmic framework to develop and prove mathematics. He also contends that throwing in the terminology and use of algorithms can be the glue to provide cohesion of a discrete mathematics course. To the best

of my knowledge there are no texts currently incorporating his ideas, although he and Anthony Ralston are writing such a book.

Some two-year colleges are already teaching discrete mathematics. I have talked with several persons where such activity is taking place. Tallahassee Community College in Tallahassee, Florida, began teaching discrete mathematics in the Winter 1984 semester. The content of this course, as indicated to me by Linda Smith, Director of the Division of Science/Mathematics, includes methods of mathematical proof and fundamentals of logic; elementary combinatorics (permutations and combinations); relations; digraphs; graphs; and trees. There are two main goals to their course: (1) to train the student to make a logical, case-by-case, clear and complete analysis of problems and (2) to introduce the student to certain facts, techniques, terminology, and concepts of enumeration theory and graph theory that will be useful in future courses. (For example, recurrence relations are beneficial in analysis of algorithms, and graphs and trees are important for data structures.) Ricks College in Rexburg, Idaho, and Menlo College in Atherton, California, also have discrete mathematics courses. I am sure there are others.

The impetus for the current interest in discrete mathematics was generated primarily by the book, The Future of College Mathematics, by Anthony Ralston and Gail Young. This book and its recommendations were discussed last year at the AMATYC Convention. The book also brought about the panel discussion on discrete mathematics and the minicourse on discrete algorithmic mathematics I attended at the MAA Convention. Others have also recommended that discrete mathematics be incorporated into the mathematics curriculum. Recent Committee on the Undergraduate Program in Mathematics (CUPM) guidelines recommend two courses in the area of finite (discrete) mathematics. One is a course in discrete methods and includes

topics from graph theory and combinatorics; the other is a course in applied algebra. ACM, the professional society of computer scientists, has similar recommendations. Furthermore, in its report, Educating Americans for the 21st Century, a commission on pre-college mathematics of the National Science Foundation (NSF) stated that discrete mathematics should be considered fundamental.

In July, 1984, at Menlo College in California 25 persons associated with mathematics education met to discuss "New Directions in Two-Year College Mathematics". I was privileged to have been one of those participants. The recommendations of that conference include discrete mathematics. One recommendation states, "Computers and other elements of information technology are changing in fundamental ways both the mathematics that it is important to learn (such as discrete mathematics, statistics, and technical mathematics) and the ways that mathematics, traditional and otherwise, can be learned. This will have profound and continuing implications for students, faculty, and the curriculum." The conference also suggested that discrete mathematics topics be included in the liberal arts or mathematics appreciation class. Finally, a conference recommendation states that, "Planning should begin immediately to deal with...the impact of the algorithmic point of view on the content of all mathematics courses." Thus, this conference, discussing the state of mathematics today in two-year colleges, recognized the importance of discrete topics in the curriculum. Note that a specific course in discrete mathematics is not recommended. The general feeling that I received from being a participant was that most felt that the topics could and should be integerated into the already existing curriculum. What I'm afraid will happen with that approach is that the computer science departments will get disgusted with the mathematics departments and develop their own courses which cover discrete topics. If that happens the mathematicians will have lost another course to a different department.

To summarize, the inclusion of discrete mathematics into the curriculum has been advocated by many credible sources. Discrete mathematics courses are found currently, but mainly at the junior/senior level. These courses are

gradually filtering down to the freshman/sophomore level. More choices of textbooks are needed at this lower level.

The major topics for such a course appear to be: sets, propositional logic, formal systems such as groups, methods of proof, graph theory, trees, relations, functions, and basic combinatorics. If probability is included, its coverage will not be in depth. Additional material for a discrete mathematics class: analysis of algorithms, matrix algebra, predicate logic, boolean algebra, and additional probability and combinatorics.

Mathematical Structures For Computer Science
Judith L. Gersting
W. H. Freeman And Company

Chapter 1 - How To Speak Mathematics: Basic Vocabulary I
Chapter 2 - How To Speak Mathematics: Basic Vocabulary II
Chapter 3 - Structures and Simulations
Chapter 4 - Boolean Algebra and Computer Logic
Chapter 5 - Algebraic Structures
Chapter 6 - Coding Theory
Chapter 7 - Finite-State Machines
Chapter 8 - Machine Design and Construction
Chapter 9 - Computability
Chapter 10 - Formal Languages

Applied Finite Mathematics
Gary G. Gilbert / Donald O. Koehler
McGraw-Hill Book Company

Chapter 1 - Systems of Linear Equations
Chapter 2 - Linear Programming
Chapter 3 - Matrix Algebra
Chapter 4 - Graphs
Chapter 5 - Probabilistic Modeling
Chapter 6 - Markov Chains
Chapter 7 - Game Theory
Chapter 8 - Mathematics of Finance

Discrete Mathematical Structures for Computer Science
Bernard Kolman / Robert C. Busby
Prentice-Hall, Inc.

Chapter 1 - Fundamentals
Chapter 2 - Relations and Digraphs
Chapter 3 - Functions
Chapter 4 - Order Relations and Structures
Chapter 5 - Trees and Languages
Chapter 6 - Semigroups and Groups
Chapter 7 - Finite-State Machines and Languages
Chapter 8 - Groups and Coding

Elements of Discrete Mathematics
C. L. Liu
McGraw-Hill Book Company

Chapter 1 - Sets and Propositions
Chapter 2 - Permutations and Combinations
Chapter 3 - Relations and Functions
Chapter 4 - Graphs and Planar Graphs
Chapter 5 - Trees and Cut-Sets
Chapter 6 - Discrete Numeric Functions and Generating Functions
Chapter 7 - Recurrence Relations
Chapter 8 - Groups and Rings
Chapter 9 - Boolean Algebras

Discrete Mathematics
Richard Johnsonbaugh
Macmillan Publishing Company

Chapter 1 - Introduction
Chapter 2 - Counting Methods and Recurrence Relations
Chapter 3 - Graph Theory
Chapter 4 - Trees
Chapter 5 - Network Models and Petri Nets
Chapter 6 - Boolean Algebras and Combinatorial Circuits
Chapter 7 - Automata, Grammars, and Languages

Discrete Mathematics for Computer Scientists
Joe L. Mott / Abraham Kandel / Theodore P. Baker
Reston Publishing Company, Inc., A Prentice-Hall Company

Chapter 1 - Foundations
Chapter 2 - Elementary Combinatorics
Chapter 3 - Recurrence Relations
Chapter 4 - Relations and Digraphs
Chapter 5 - Graphs
Chapter 6 - Boolean Algebras

Mathematics for Data Processing
David Wheaton
Wadsworth Publishing Company

Chapter 1 - Evaluations, Sets, Numbers, and Flowcharts
Chapter 2 - Decimal and Non-Decimal Systems of Numeration
Chapter 3 - Logic
Chapter 4 - Polynomials
Chapter 5 - Solving Equations and Inequalities
Chapter 6 - Algebraic Fractions
Chapter 7 - Linear Function and Writing Formula
Chapter 8 - Solving Systems of Equations
Chapter 9 - Exponents, Radicals, and Scientific Notation
Chapter 10 - Rational Numbers in Non-Decimal Bases
Chapter 11 - Quadratic Equations and Radical Equations
Chapter 12 - Non-Linear Functions
Chapter 13 - Matrices
Chapter 14 - Linear Programming
Chapter 15 - Boolean Algebra
Chapter 16 - Progressions

TABLE OF CONTENTS: Discrete Mathematics
Polimeni and Straight
Brooks/Cole Publishers
a manuscript with a tentative publication date of January, 1985.

Logic - Logical Connective and Equivalence; alternative statement forms; quantifiers, methods of proof
Set Theory - includes cardinality and counting, permutations and combinations
Relations - includes partial order relations and n-ary relations.
Functions - includes recursion and iteration
Algebraic Structures
Graph Theory

TABLE OF CONTENTS: unnamed Prospectus for first-year Discrete Mathematics course to be ready for class testing by Fall 1985.
Scott Foresman Publishers

Combinatorial Problems and Techniques - includes sets, mathematical induction and binary arithmetic
Graphs - includes matrix arithmetic and complexity theory sections
Matching
Trees
Networks
Counting
Recurrence Relations - includes first order linear difference equations and types of algorithms
Logic circuits and machines
relations, partitions, and functions.

"What is a Discrete Mathematics Course?", results of a survey by Kenneth P. Bogart, Dartmouth College, with assistance from D.C. Heath and Co. Publishers

Table showing the 18 most popular topics for inclusion in a Discrete Mathematics Course

TOPIC	PERCENT OF RESPONDANTS INCLUDING	PERCENT OF RESPONDANTS EXCLUDING
Set Theory	83	6
Permutations	83	6
Combinatorics	82	8
Graph Theory	82	6
Relations	81	5
Trees	81	7
Mathematical Induction	80	8
Equivalence Relations	79	6
Functions	78	5
Truth Tables	75	12
Recurrence Relations	73	12
Partitions	72	11
Recursive Definition	72	13
Propositional Logic	71	13
Boolean Algebra	66	13
Partial Orderings	62	15
Probability	62	23
Numeric Functions	55	17